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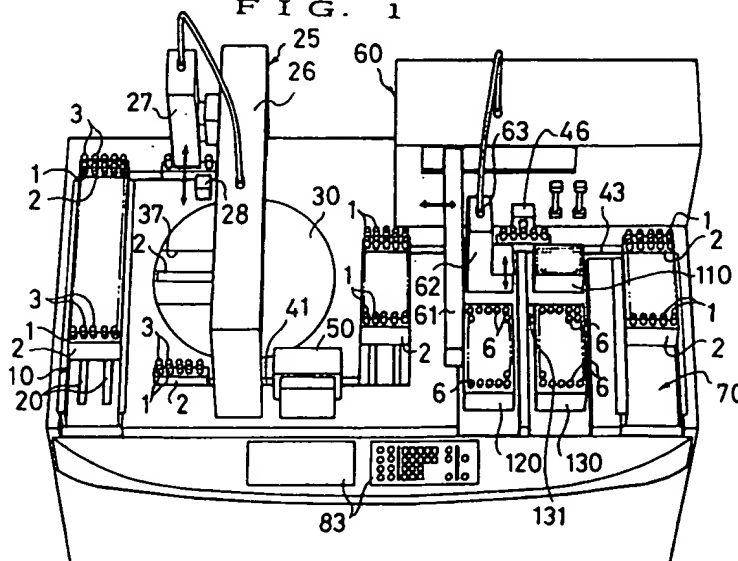
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(54) Sample preparation apparatus.

(57) A fully automated prework station comprises: a first conveyor line (20) for carrying sampler containers (1) to an automatic centrifuge; an automatic centrifuge (30) located near a terminating end of the first conveyor line; a second conveyor line (40) for transporting the sampler containers that have undergone a centrifugal separation process in the centrifuge to a specimen extraction position; an automatic plug opening device (50) installed halfway in

the second conveyor line; a specimen extraction and distributed delivery device (60) for drawing specimens from the sampler containers that were unplugged by the automatic plug opening device and then delivering and distributing each of the extracted specimens among other containers (6) each assigned with a specific inspection; and a control means (80) for controlling the devices in a coordinated way.

FIG. 1



EP 0 629 858 A1

The present invention relates to sample preparation apparatus or a prework station for processing specimens of, for example, blood, before they are analysed.

In order to prevent blood infection accidents, to achieve a reduction in labor and to facilitate real time diagnosis, various experimental attempts have been made in recent years not only to enable automatic performance of analyses such as clinical biochemical and immunological analysis of blood, but also to permit automatic transfer of sampler containers containing blood to an automatic analyzing apparatus.

Conventional preprocessing of specimens currently requires the intervention of many people. The following are examples of the type of operations which are performed: feeding sampler containers such as sampler tubes containing sampled blood to a centrifuge where they are subjected to a centrifugal separation process; removing rubber plugs from the sampler containers that have undergone the centrifugal separation process; and drawing specimens from the unplugged sampler containers and distributing each of the extracted specimens among other sampler containers, each assigned for a specific type of analysis. In the centrifugal separation process, for example, the sampler containers are mostly processed in batches by a person handling individual sampler containers. The unplugging of containers is also done manually. The process of delivering and distributing the extracted specimen among different inspections is carried out mostly manually, although an automatic specimen extraction and distributed delivery apparatus is employed in parts of the process. In this way, a series of processes is interrupted by manual operations. While highly sophisticated techniques have already been introduced into inspection equipment and an information processing field, there is little improvement observed in automating the prework or preprocessing systems. Under these circumstances, improvements of the prework systems have been strongly called for.

According to a first aspect of the invention there is provided sample preparation apparatus comprising: a first conveyor for carrying sampler containers; a centrifuge arranged to receive the sampler containers from the first conveyor; a second conveyor for transporting the sampler containers that have undergone a centrifugal separation process in the centrifuge to a specimen extraction and delivery device; a plug opening device arranged adjacent to the second conveyor; the specimen extraction and delivery device being arranged to draw specimens from the sampler containers that have been plugged by the automatic plug opening device and then to deliver and distribute each of the extracted specimens among other con-

tainers for analysis; and a control means for controlling the devices in a coordinated way.

According to a second aspect of the invention there is provided a fully automated prework station, comprising a first conveyor line for carrying sampler containers to an automatic centrifuge; an automatic centrifuge located near a terminating end of the first conveyor line; a second conveyor line for transporting the sampler containers that have undergone a centrifugal separation process in the centrifuge to a specimen extraction position; an automatic plug opening device installed halfway in the second conveyor line; a specimen extraction and distributed delivery device for drawing specimens from the sampler containers that were unplugged by the automatic plug opening device and then delivering and distributing each of the extracted specimens among other containers each assigned with a specific inspection; and a control means for controlling the devices in a coordinated way.

Thus it will be seen that, at least in preferred embodiments, there is provided a fully automated prework station that can automatically perform, in a coordinated way, and without requiring human intervention, a series of operations or processes. These processes include: carrying the sampler containers and setting them in position in the centrifuge; unplugging the sampler containers that have undergone the centrifuging operation; transferring the unplugged sampler containers to the specimen extraction position; drawing specimens from the sampler containers that have arrived at the specimen extraction position; and delivering specified amounts of the specimens into subcontainers each assigned for a specific analysis or inspection.

A preferred embodiment of the invention will now be described, by way of example only and with reference to the accompanying drawings, in which:

Figure 1 is a perspective view showing the overall construction of a fully automated prework station according to one embodiment of this invention; and

Figure 2 is a plan view showing the schematic overall configuration of the fully automated prework station of Figure 1.

The fully automated prework station of this embodiment, as shown in Figure 1 and Figure 2, includes: specimen or sampler containers, containing sampled blood; racks 2 each accommodating a plurality of sampler containers J (in this case, five) in upright positions; a first conveyor line 20 that carries the sampler containers J held in the racks 2 from a sampler container stocker 10 to a pickup position a; an automatic centrifuge 30 installed near the terminating end of the first conveyor line 20; a

second conveyor line 40 that transports the sampler containers 1 that underwent the centrifugal separation process in the centrifuge 30 to an extraction position e; an automatic plug opening device 50 installed on the second conveyor line 40; a specimen extraction and distributed delivery device 60 that draws a required portion of the sampled blood from the open container 1 and delivers the extracted blood specimen into subcontainers 6 for inspection; a processed container stocker 70 that stocks racks 2 holding the sampler containers 1 that have undergone the specimen extraction and distributed delivery process; and a controller 80 that controls these devices in a coordinated way. Reference numeral 90 represents an information input section.

The sampler container 1 is similar in construction to a known blood sampling tube U-shaped in cross section, with its upper opening sealed with a plastic sheet seal or rubber plug 3. The sampler container 1 has attached on its outer circumferential surface a bar code label (not shown) carrying information related to the sample blood, such as patient's name, registered identification number and sex, category of health insurance, insurance policy number, and the kind of inspection to be performed. A means for encoding these information into bar codes is well known and thus detailed explanation for the encoding means is omitted here.

The rack 2 is constructed to hold a plurality of sampler containers 1 (in the embodiment, five containers) in an upright attitude and is stuck on its outer surface with a bar code label (not shown) carrying a rack number. The rack number may be recorded by using such known means as a magnetic storage medium or a number of small holes through which light passes. The rack 2 with the sampler containers 1 erected therein is set in the sampler container stocker 10. The sampler container stocker 10 accommodates a row of racks 2, which are then fed intermittently to the pickup position a by the first conveyor line 20.

The first conveyor line 20 comprises a longitudinal feed device 21 having two parallelly arranged endless belts, a drive unit (not shown) that intermittently drives the longitudinal feed device 21 at constant intervals, a lateral feed device 22 installed at the terminating end of the longitudinal feed device 21, and a drive unit (not shown) that intermittently drives the lateral feed device 22. The pickup position a is located where the rack 2 carried over by the lateral feed device 22 stops. The longitudinal feed device 21, the lateral feed device 22 and their drive units may be formed by using an appropriate combination of a known endless belt intermittent drive mechanism and a rack intermittent feed mechanism using a timing belt. So their de-

tailed explanation is not given here.

The rack 2, which has been transported to the pickup position a by the first conveyor line 20 in this way, is now set in the automatic centrifuge 30 by a pickup robot 25.

As shown in Figure 2, the pickup robot 25 consists of: a guide rail 26 laid parallel to the longitudinal feed device 21 of the first conveyor line 20; a clasper 27 arranged slidable along the longitudinal direction of the guide rail 26 and also vertically movable; and a drive unit (not shown) for driving the clasper 27. The guide rail 26 is constructed in the similar manner to the known feed mechanism using a timing belt. The clasper 27 is the same as the one used in a known pickup robot. So, detailed explanation for these members is not needed.

The pickup robot 25 with the above construction is controlled to clamp the rack 2 or dummy cassette 7 that was transferred to the pickup position a and install it onto a rotor (not shown) in the automatic centrifuge 30 through a window 31 formed in the centrifuge 30, or is controlled to take the centrifugalized rack 2 out of the rotor and onto the starting end c of the second conveyor line 40.

The dummy cassette 7 is used to maintain the rotating balance when the rack 2 is set on the rotor in the automatic centrifuge 30, and is arranged parallel to the pickup position a. The dummy cassette 7 is transferred to a dummy cassette standby position b in synchronism with the transfer of the rack 2 by an automatic feeding device not shown.

At the pickup position a is installed a bar code reader 28 of a known construction which reads the identification number of a rack about to be subjected to the centrifugal separation processing.

The automatic centrifuge 30 has a transparent or translucent cover 32 enclosing the rotor and the rotor drive unit to prevent the accidental trapping of hand. Mounting and demounting of the rack 2 and the dummy cassette 7 to and from the centrifuge 30 by the pickup robot 25 is done through the window 31 formed in the cover 32. In other aspects, the construction and workings of the centrifuge in this embodiment are similar to those of a known batch processing type centrifuge, and thus its detailed explanation is omitted.

It is also possible to apply the Patent No. 1523287 (Japanese Patent Publication No. 10267/1989) filed by this inventor to this embodiment and construct the automatic centrifuge 30 so that it can perform the centrifugal separation continuously, thereby substantially reducing the standby time of the rack 2. The window 31 may be provided with a known shutter mechanism that opens and closes the window 31 in synchronism with the mounting and demounting of the rack 2 and dummy cassette 7 by the pickup robot 25.

The rack 2 (and therefore the sampler containers 1 containing sampled blood and held in the rack 2), which has undergone the centrifugalizing process in the automatic centrifuge 30, is transferred by the pickup robot 25 onto the starting end c of the second conveyor line 40. After this, the dummy cassette 7 is automatically removed by the pickup robot 25 from the rotor and returned onto the standby position b.

The second conveyor line 40 includes: a lateral feed belt device 41; a longitudinal feed belt device 42 installed at the terminating end of the lateral feed belt device 41; and a specimen extraction lateral feed belt device 43. The rack 2 set at the starting end c of the lateral feed belt device 41 is moved to the terminating end of the belt device 41, from which it is transferred onto the longitudinal feed belt device 42. When the rack 2 reaches the terminating end of the longitudinal feed belt device 42, it is then transferred onto the specimen extraction lateral feed belt device 43, which feeds the rack to the specimen extraction position e set halfway in the belt device 43.

The second conveyor line 40 of the above construction has a plug opening position d set halfway in the lateral feed belt device 41 where a stopper 44 and an automatic plug opening device 50 are arranged. At the specimen extraction position e in the lateral feed belt device 43, a stopper 45 is installed and, on the immediate upstream side of the specimen extraction position e, a bar code reader 46 is arranged to read the rack identification number.

The stopper 44 closes and opens the path of the lateral feed belt device 41 so that the rack 2 that has reached the plug opening position d is stopped there by the stopper 44 until the sampler containers in the rack 2 are removed of their rubber plugs 3.

The second stopper 45 also closes and opens the path of the specimen extraction lateral feed belt device 43 so that the rack 2 that has reached the specimen extraction position e is stopped there by the stopper 45 until the required portion of the blood in the sampler container 1 held in the rack 2 is drawn and delivered into subcontainers for inspection.

The longitudinal feed belt device 42, the lateral feed belt device 41, the specimen extraction lateral feed belt device 43 and their drive units 47, 48, 49 may be formed in a way similar to that in which the first conveyor line 20 is formed, i.e. by properly combining a known endless belt drive mechanism and a rack intermittent feed mechanism using a timing belt. Thus the detailed description of the second conveyor line is omitted here. The bar code reader 46 also is of a known construction and thus its detail is not given here.

The automatic plug opening device 50, which is located at the position d in the lateral feed belt device 41 to remove the rubber plugs 3 from all of the sampler containers 1 held upright in the rack 2, may apply the known automatic plug opening mechanism disclosed by Japanese Patent Laid-Open No. 178394/1993 (Japanese Patent Application No. 361092/1991) filed by this applicant. Hence, its detailed description is omitted here.

The specimen extraction and distributed delivery device 60 comprises: a laterally movable rail 61; an arm 62 slidable along the longitudinal length of the rail 61 between the near and the far side thereof and also vertically movable; and a pipet device 63 mounted on the arm 62. The movement control mechanism for the rail 61 and the slide and lift control mechanism for the arm 62 are similar to those of a known X-Y feed mechanism, and hence their detailed description is omitted. Furthermore, the pipet device 63 is also similar in construction to the known pipet device found in common automatic analysis equipment. So, its detailed description is not necessary.

When the rack 2 arrives at the specimen extraction position e, the specimen extraction and distributed delivery device 60 of the above construction moves the arm 62 to a position over a tip rack 100 or 110 and lowers it to fit an unused disposable tip over the free end of a pipet (not shown) of the pipet device 63.

Then, the arm 62 is lifted above the specimen extraction position e before being lowered to dip the free end of the pipet (i.e. disposable tip) into the blood serum in the sampler container 1 held upright in the rack 2. The pipet device 63 is activated to draw a required amount of serum and then lifted and moved over a magazine 120, 130 that holds a plurality of subcontainers 6 in upright condition.

When the arm 62 is moved to a predetermined position above the magazine 120, 130, it is lowered to insert the free end of the pipet (i.e. disposable tip) into the subcontainer 6 and deliver a specified amount of the extracted serum. The delivery of the extracted serum is carried out continuously for a plurality of subcontainers the number of which corresponds to that of the specified inspection items.

After the extraction and distributed delivery of blood serum is completed in this manner, the arm 62 is moved up to the original position where the disposable tip is removed and discarded while at the same time the interior of the pipet is cleaned by clean water supplied from a cleaning device (not shown) connected to the pipet device 63. This cleaning operation is performed before the above-mentioned specimen extraction and distributed delivery operation is repeated.

In this embodiment, 50 subcontainers 6 are accommodated, in upright position, in each of the two magazines 120, 130, with the magazine 120 dedicated for biochemical analysis and the magazine 130 for immunological analysis. These magazines may also be used in other way, for example, to meet the requirements of a customer. The number of the magazines may be changed according to the requirements.

By the side of the magazines 120, 130 are installed magazine readers 121, 131 which reads magazine identification numbers indicated in the form of bar codes. These magazine readers 121, 131 are of the same construction as the rack identification number reader and thus its detailed description is omitted here.

The processed container stocker 70 receives and stocks the racks 2 holding the sampler containers 1 that have undergone the specimen extraction and distributed delivery operation. That is, the racks 2 fed to the terminating end of the specimen extraction lateral feed belt device 43 are pushed and transferred one after another onto the processed container stocker 70 by the longitudinal feed device 71.

The controller 80, which incorporates a computer (CPU), controls the above-mentioned mechanisms in a coordinated way and checks the rack identification numbers read by the bar code readers 28, 46 against the magazine identification numbers read by the magazine readers 121, 131 to ensure that the specimen extraction and distributed delivery operation is correctly carried out. The controller 80 also monitors and controls the mounting condition of the racks 2 in the automatic centrifuge 30 as well as the duration of the centrifugal separation operation.

The controller 80 is connected with a power supply 81, a printer 82, a display (such as CRT) and keyboard 83, and an IC card reader 84 so that the management data about the state of the centrifugal separation operation and of the specimen extraction and distributed delivery operation being performed can be displayed in real time and printed out. The IC card reader 84 reads from an IC card (not shown) an identification number of a prework station operator and a program specifying the prework conditions, and loads the program into the controller 80. The prework station is controlled according to this program. The control conditions may also be entered directly from the keyboard 83.

It is possible to enter control requirements into the controller 80 from an information input unit 90, an external terminal for the controller, through a telephone line and also to monitor the result of the specimen extraction and distributed delivery operation as well as the operating state of the station. This makes it possible to check the cause of a

trouble and direct the repair procedure without going to the installation site.

The information input unit 90 includes a computer (CPU) 91, a display (such as CRT) and keyboard 92 and a printer 93.

The preferred fully-automatic prework station described above is capable of performing, without requiring human interventions, a series of operations-a process of carrying and setting the sampler containers in the centrifuge, a process of unplugging the sampler containers that have undergone the centrifuging operation, a process of transferring the unplugged sampler containers to the specimen extraction position, and a process of drawing a specimen from the sampler containers that have arrived at the specimen extraction position and then delivering and distributing specified amounts of the specimens among subcontainers each assigned with a specific inspection. Among various advantages, the prework station can reliably prevent blood infection accidents. Further, since these processes can be coordinated and automatically controlled, they can be performed swiftly with no loss of time, thereby substantially reducing the time it takes to finish inspections.

Claims

1. Sample preparation apparatus comprising: a first conveyor for carrying sampler containers; a centrifuge arranged to receive the sampler containers from the first conveyor; a second conveyor for transporting the sampler containers that have undergone a centrifugal separation process in the centrifuge to a specimen extraction and delivery device; a plug opening device arranged adjacent to the second conveyor; the specimen extraction and delivery device being arranged to draw specimens from the sampler containers that have been unplugged by the automatic plug opening device and then to deliver and distribute each of the extracted specimens among other containers for analysis; and a control means for controlling the devices in a coordinated way.
2. Sample preparation apparatus as claimed in claim 1, wherein the centrifuge is located near an end of the first conveyor.
3. Sample preparation apparatus as claimed in claim 1 or 2, wherein the plug opening device is located approximately halfway along the second conveyor.
4. Sample preparation apparatus as claimed in any preceding claim, wherein the control means comprises an electronic central pro-

cessing unit.

5. Sample preparation apparatus as claimed in any preceding claim, comprising bar code reading means to read bar codes on the sampler containers. 5

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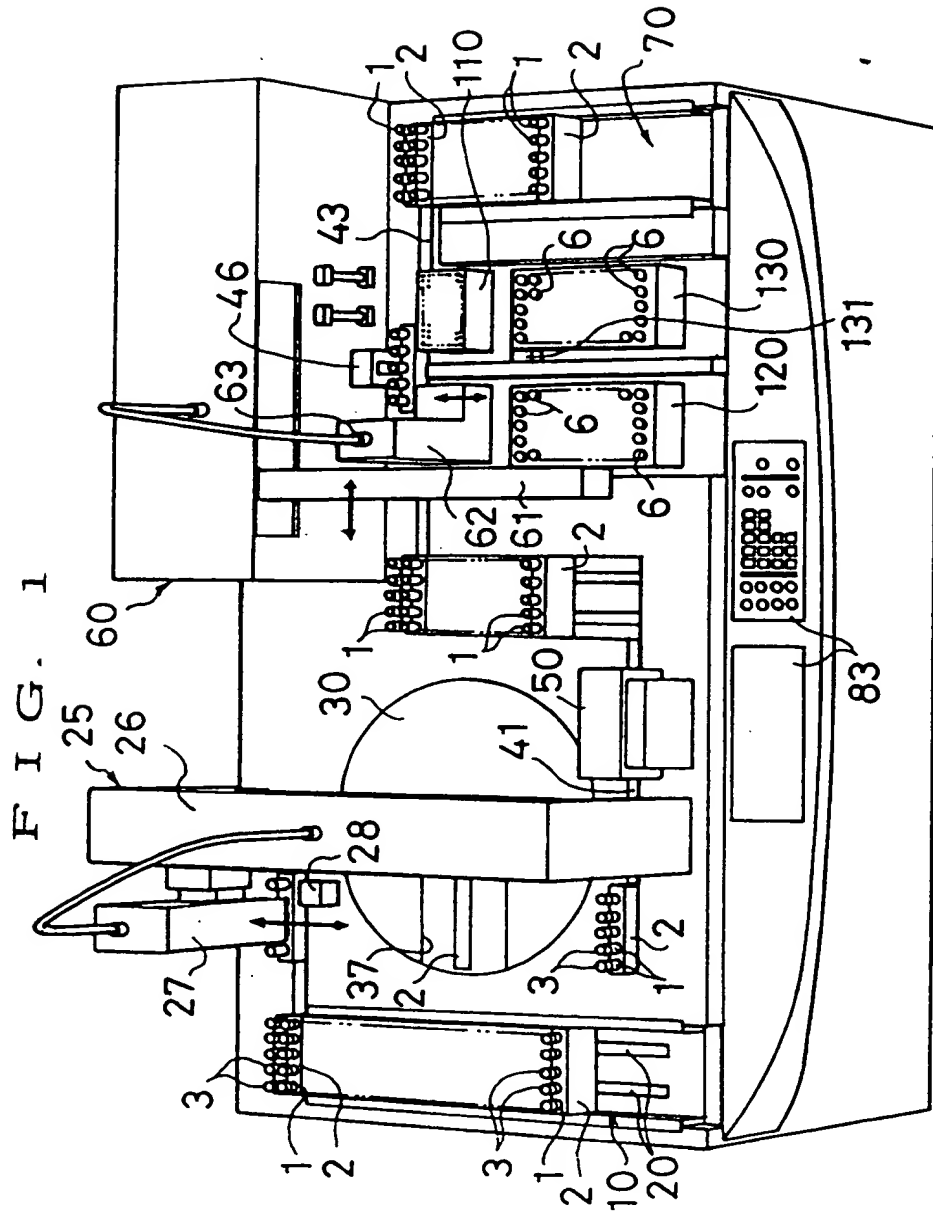
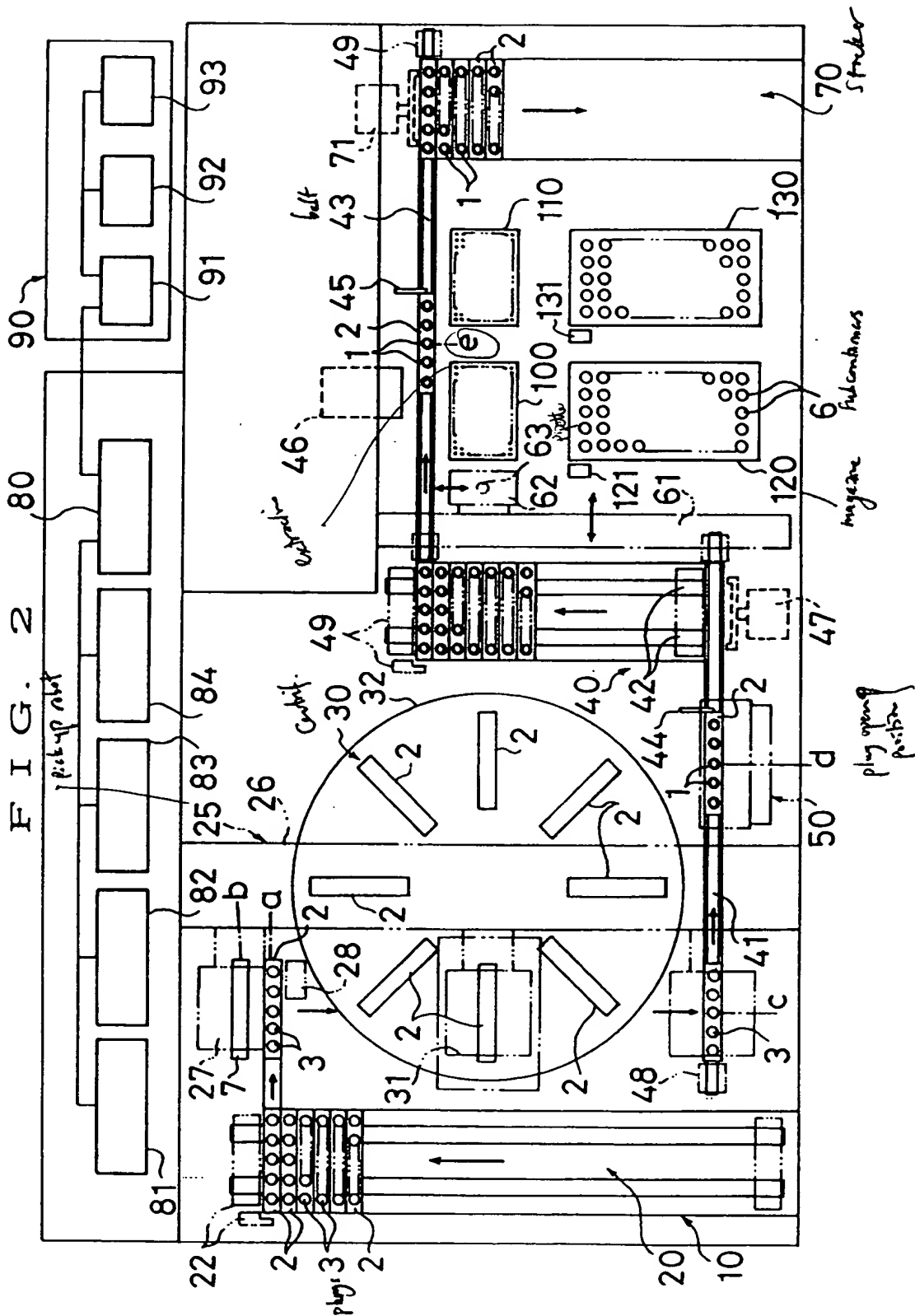


FIG. 2





European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 93 30 8368

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. CL.5)
Y	US-A-3 635 394 (NATELSON) * column 1, line 45 - line 57; figures 1,6,10 * * column 6, line 20 - line 27 * ---	1-5	G01N35/02 B67B7/02-
Y	EP-A-0 243 915 (ITOH) * page 1, line 2 - line 22 * * page 11, line 6 - page 12, line 22; figure 1 * ---	1,2,4,5	
Y	EP-A-0 264 456 (ITOH) * page 1, line 6 - line 13; figures 11-18 * * page 6, line 20 - line 34; figure 1 * ---	3	
A	DATABASE WPI Section Ch, Week 8948, 1989 Derwent Publications Ltd., London, GB; Class B04, AN 89-352399 C48 & JP-A-1 263 558 (HITACHI) 15 April 1988 * abstract * ---	1	
A	WO-A-90 03834 (MEDICAL AUTOMATION SPECIALTIES) * page 7, line 8 - page 8, line 24 * ---	1-5	TECHNICAL FIELDS SEARCHED (Int. CL.5) G01N
A	WO-A-91 08491 (CHATEAU) * abstract; figures * ---	1	
A	WO-A-89 06206 (R&D TOOL COMPANY) * abstract; figures * * page 19, paragraph 1 - paragraph 2; figure 2 * -----	3	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 12 September 1994	Examiner Hocquet, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application I : document cited for other reasons A : member of the same patent family, corresponding document			